Glass and Ceramics, Vol. 69, Nos. 11 – 12, March, 2013 (Russian Original, Nos. 11 – 12, November – December, 2012)

RAW MATERIALS

UDC 691.619.8

WAYS TO SUPPLY GABBRO-BASALT RAW MATERIALS TO MINERAL FIBER PRODUCERS

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Translated from *Steklo i Keramika*, No. 12, pp. 17 – 21, December, 2012.

Ways to use gabbro-basalt raw material for the production of mineral wool and industry's demand for it are examined. The reasons for quality and composition variations of the raw material are shown. Recommendations for solving the raw material problem are made for producers — preparation of domestic deposits based on geological prerequisites, mineral-technological mapping of objects and organization of selective raw materials production.

Key words: mineral wool, gabbro-basalt raw material, composition, deposit.

Different raw material components are used in the production of mineral wool, but aluminum-silicate magmatic rocks of the main series comprise the largest part — gabbroids, basaltoids and their metamorphosed variations. These rocks are common in nature. However, most producers of mineral fiber have problems with quality control and variation of the gabbro-basaltic raw materials composition. The sources of these problems are to be found in the lack of readiness of the existing mineral raw-materials resources. It should be noted that the raw materials used for the production of mineral fiber are not standardized.

Usage of and Industry Demand for Gabbro-Basaltic Raw Materials

It is recommended that magmatogenic basic and medium rocks with a wide chemical and mineralogical composition be used in the production of stone fiber (%)[5]: 38 – 55 SiO_2, 3 – 20 Al_2O_3, 17 CaO_2, 1 – 24 MgO, 2 – 18 ($FeO + Fe_2O_3$), to 0.3 MnO [1, 2]. However, experience shows that three ways with vastly different approaches toward and requirements for raw materials have now emerged for the use of gabbro-basaltic raw materials (GBR) in the production of mineral wool:

1) for compositing blast furnace slag in the process of obtaining slag wool;

2) in the production of basalt fiber with the conventional composition;

3) for obtaining high-alumina basalt fiber.

Slags are distinguished by high content of calcium oxides and give an acidity modulus in the range 0.8 – 1.3. For this reason, GBR are used in the production of mineral fiber based on slag to increase the acidity modulus and, correspondingly, the fiber quality. Their fraction in batch usually does not exceed 30%. Considering the possibility of compositing, rocks with a quite wide chemical composition can be used in this direction (%): 46 – 58 SiO_2, 4 – 20 Al_2O_3, 4 – 20 CaO, 4 – 20 MgO [1, 3].

To obtain high-quality basalt wool the quality of gabbro-basalt raw material is decisive. Modern industry strives to obtain high-quality product at the lowest cost, and GBR with acidity modulus 2 – 3, capable of serving as a one-component raw material or with slight compositing, meets this requirement. Raw material is required to meet more stringent requirements. These are low-silica (42 – 48% SiO_2) and high calcium-magnesium ($\geq$ 15% CaO + MgO) gabbroids and basaltoids. Raw material with this composition is now in high demand by basalt wool producers.

The desired modulus is reached in the production of *high-alumina fiber* by increasing the aluminum oxide frac-

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tion. Only low-silica aluminum-silicate rocks with the composition 41 – 50% SiO_2, 19 – 30% Al_2O_3, 12 – 22% CaO and 0.5 – 9% MgO are suitable for obtaining fiber of this type. Such a chemical composition is characteristic of intrusive rocks (deep crystallization rock) in the anorthosite series — anorthositic gabbro. Considering that the replacement of silicon by aluminum in the fiber composition has a positive effect on not only its biosolubility but also its elasticity, in recent years there has been a trend toward increasing the aluminum oxide fraction in the batch. For such purposes it is best to use gabbroids, and less often basaltoids, with elevated aluminum content.

It is known that the desired composition can be obtained by compositing, but a one-component composition can also be used. The use of multicomponent compositions intensifies the anisotropy of the medium in the melting tank and, correspondingly, shortens the maintenance-free operating time and increases the consumption of expensive refractories. When carbonates are added to the batch — dolomites and limestones — copious amounts of CO_2 gas are released, which causes the melt to foam and results in environmental contamination. Because of their higher heat capacity carbonates required three or more times more energy to be heated to the required temperature than the same volume of gabbro-basalts. In practice producers strive to lower the amount of compositing material and ideally to switch to a one-component composition.

Sources of Gabbro-Basalt Raw Material and Mineral-Raw Materials Resources Status

The problem of furnishing mineral-wool producers with gabbro-basalt raw material can be solved as follows:

– using crushed gabbro-basaltic rock from construction stone deposits;

– co-production of gabbro-basalts in operating deposits of other types of mineral and non-mineral raw materials, where they participate in the capping structure;

– deposits deliberately prepared to supply raw materials for mineral wool production.

Each of the sources listed above possesses positive and negative aspects.

When construction stone is used there is no need for large capital investments in a mining subdivision. Crushed rock is cheap. Crushed rock deposits and the requisite production enterprises are relatively common. For example, in the mineral reserve balance of the Russian Federation there are 59 construction stone deposits with basic magmatic rocks in the Ural region alone. Of these 22 deposits are now under development. The production capacity of the enterprises producing the crushed stone ranges from 10^5 to 10^7 tons/yr, many-fold greater than the demand for crushed stone by stone fiber producers.

One would think that this is a simple solution to the raw-materials problem. But analysis reveals that the overwhelming majority of the objects are incapable of serving as a source of GBR. This is due to an industry principle for preparing deposits. Their choice and preparation for use are usually determined by the logic of crushed stone production, where the strength of the stone and the logistics of an object are the main selection criteria. For many such deposits the chemical and mineralogical composition of thick gabbroid and vulcanite bodies are characterized only by single point samples. An evaluation of a deposit as a raw material for obtaining mineral wool has been made only for some objects and was limited to tests performed on single, non-systematically chosen samples, neglecting the possible nonuniformity of the geological bodies. The compositional nonuniformity of gabbroid and basaltoid bodies is related with geological factors such as differentiation (separation) of the melt, nonuniform cooling, entry of melt portions with different composition and others. For this reason, quality ***indicators of the delivered raw material are accidental.*** It can happen that raw material which is unsuitable for high quality appears at the production plant from the same object.

The problem can be solved only by organizing ***selective*** (separate) ***production*** of raw material from mineral wool. Thus, even positively evaluated construction stone deposits require purposeful preparation of suitable and relatively uniform raw material blocks suitable for selective extraction, which is possible only if ***specialized geological exploration operations, including large-scale mineral-technological mapping, are conducted.*** On the basis of the results corrections must be made to the development plans for given deposits and to yearly plans for mining operations.

As an example, the results of such large-scale mapping, which we performed in one area of the Aznalovskii Massif of metamorphosed basaltoids, represented by the interbedded variations differing in composition and texture as well as by technological properties, are presented in Fig. 1. For raw material for mineral wool production we found only two limited blocks of rock, distinguished by high technological properties. It should be noted that this massif is shown as being uniform in the inventory of the basaltoid reserves in this section.

Logically speaking, mining enterprise should be the ones to solve these problems. However, as a rule, domestic (and not only) stone production enterprises do not have a geological division or the ability to perform compositional monitoring of the product produced in terms of meeting the requirements developed for mineral wool producers. In most cases, the crushed stone plants prefer to increase sales of simple and understandable crushed stone and not be bothered with orders from discerning customers.

A largely similar situation developed during the organization of ancillary production at deposits of other minerals. Gabbroids and basaltoids are no rarities here. Only in the Urals region are they present within 29 developed mineral deposits (chalcopyrite, iron ore, bauxite, chromite). They have also been found in 16 deposits of non-mineral raw materials (facing stone, flux, asbestos). However, most mines are concentrated in the hands of large mining-metallurgical holdings. Their main problem is to meet the needs of ferrous

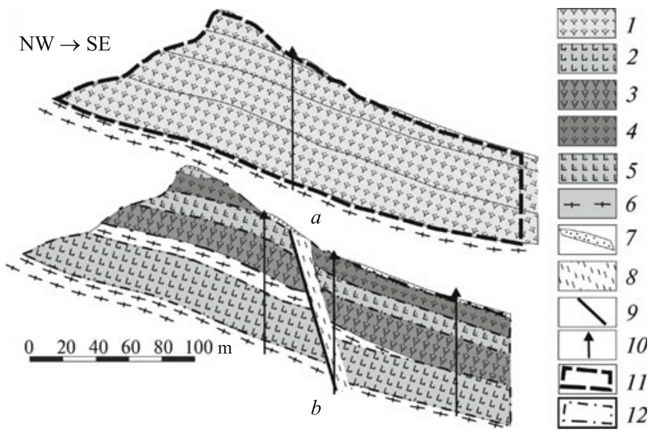

Fig. 1. Comparison of the schematic sections of a basaltoid rock massif in the Aznalovskii section (Southern Urals), constructed from data obtained from geological exploratory work on construction stone (*a*) and from the results of technological mapping during quality evaluation of raw material for mineral wool production (*b*): *1*) basaltoids for construction stone (basalts and their crystallized variations) dolerites); *2*) amygdaloidal basalts with acidity modulus **3.1**; *3*) dolerites with acidity modulus **2.6**; *4*) dolerites with acidity modulus **2.4**; *5*) andesite basalts with acidity modulus **3.9**; *6*) chlorite schists; *7*) slope loams, debris and fill; *8*) quartz veins; *9*) faults; *10*) boreholes; *11*) contour of a block of basaltoids for inventorying construction stone reserves; *12*) contours of blocks of dolerites recommended for use in mineral fiber production.

and non-ferrous metallurgy. Solving ancillary problems is often viewed as an unnecessary burden.

In summary, given the orientation toward supplying mineral-wool producers with material from active quarries in concert with mining enterprises it will be necessary to make efforts to organize selective extraction of minerals and to monitor raw-materials quality.

Supplies can be obtained from objects ***purposefully prepared*** for use in the production of mineral wool by using deposits explored in the past or by purposeful preparation of the object itself.

By 1993 eleven GBR deposits with total reserves 93.7×10^6 tons were prepared with government assistance in the Russian Federation (Table 1).

Analysis of the geological materials and technological tests shows that no deposit possesses high-quality raw material, fully meets customer demands or can serve as a reliable source of minerals as raw materials. This situation is due to the previously and currently existing disconnects between actual producer demands and the government mechanism for preparing deep strata. Specifically, in Central Russia clay deposits have for a long time been prepared as sources of raw materials for obtaining mineral wool, even though it was obvious since the beginning of the 1960s that this form of raw material is unsuitable. It should be noted that mineral wool production in the USSR was developed predominately in Ukraine, where attempts were made to create a high-quality mineral raw materials base. Attempts to comprehend and

TABLE 1. Reserves of Gabbro-Basalt Raw Material in Deposits for the Production of Mineral Wool (Data from the State Register of Mineral Reserves in the Russian Federation as of January 1, 1993).

Deposit	Region	Reserves, 10^3 m^3	
		$A + B + C_1$	C_2
Golodai-Gora (gabbro-diabase)	Republic of Karelia	36,474	–
Rop-Ruchei (gabbro-diabase)	Republic of Karelia	4427	–
Khavchozerskoe (pyroxene porphyrite)	Republic of Karelia	4715	–
Khrutorozhinskoe (gabbro-diabase)	Orenburg Oblast’	32,363	–
Bilimbaevskoe (shale, prophyrite)	Sverdlovsk Oblast’	447	–
Ilyushkin Klyuch (basalt)	Republic of Buryatiya	2447	–
Pritrassovoe (gabbro)	Magadan Oblast’	2062	1928
Naladnoe (gabbro)	Magadan Oblast’	3107	–
Marusinskoe (basalt)	Khabarovskii Krai	390	–
Chlyanskoe (basalt)	Khabarovskii Krai	168	–
Dorozhnoe (metabasalt)	Primorskii Krai	1702	4584

create an adequate GBR mineral raw materials base for mineral wool were made in the late 1980s in Karelia (work at the Karelia Institute of Geology) and in the southern part of Sverdlovsk Oblast’ (work by Industrial Geophysical Union Uralgeologiya).

In the last few years, using Federal budgetary means, work was organized on the preparation of deposits in the Northern Ossetia and the Republic of Bashkortostan. However, the lack of clear requirements for raw material and for generalizing predictive-minerogenic works is making it necessary to choose objects randomly for geological study and as a result some of the prepared objects are of no interest under present conditions. At the same time promising geological bodies remain unstudied and unprepared.

The existing mineral-raw materials base formed accidently, and its status in no way reflects the true mineral potential in the Russian Federation.

Nonetheless, the deep-interior potential is enormous in Russia. There are numerous intrusive and volcanic complexes on Russian territory, which were formed in diverse situations and conditions — in the deep interior of ancient shields, on island volcanic arcs, in zones of collisions of continents and spreading (expansion) of the ocean bottom and others. Magmatic rocks with basic composition, generated under different geological conditions, are also distinguished by mineralogical and chemical composition. The natural formations with the most favorable composition for obtaining mineral wool occupy regular positions in the mosaic of geological formations.

Thus, vulcanites are extremely widely developed in island complexes, but the large participation of high-silica pri-

mary-sedimentary crustal material in their formation predetermines their andesitic specialization and high content of silicic acid and makes discovery of rocks suitable for mineral wool unlikely. And, conversely, the formation of basalts in zones of continental splitting with the participation of mantle materials results in depletion of their silicic acid (right to picrites) and enrichment with magnesium compounds. Rocks characterized by low melt viscosity which are suitable for mineral wool as a one-component raw material can be found in these complexes.

Taking account of the regularities in the localization of productive complexes of gabbro-basaltic rocks makes it possible to predict objects with prescribed properties and determine the potential possibilities of territories with different geological structure.

The number of potential sources of gabbro-basaltic raw materials is large. Only within the Urals region are 300 geological formations, including magmatic and volcanic bodies of basic composition and their metamorphosed analogs, are to be found. Such diversity largely predetermines success in choosing a promising object. The preparation of a proper object and the subsequent organization of mining enterprises require investments but they also make it possible to take account the demand for domestic production as fully as possible. In the course of geological exploration blocks of mineral reserves must be prepared by technological type and sorts, separated according to the results of preliminary technological tests. Taking account of the existing data on the yield of the required fraction for mineral wool production from 30 to 60% of the total volume of the worked rock mass, it is also necessary to secure a market for ancillary crushed rock production.

A number of Russian manufacturers of mineral wool have gone down the path of creating their own mineral raw materials base. Reserves of high-quality gabbroids have been prepared within the Bazhenovskoe asbestos deposit in Sverdlovsk Oblast' (Ékover, JSC; Uralacbest, JSC), and same for basaltoids in the Nizhetur'inskoe deposit (Tizol, JSC). Basaltoids within the Vezhayu-Vorykvinskoe bauxite ore field of the Komi-Permyakskoe autonomous district, where the RUSAL company is implementing plans to develop its own production of mineral wool, can be prepared in the next few years.

Mineral wool manufacturers are unjustified in counting on government assistance in the preparation of a raw materials base.

The approach of one world leader in the production of stone wool — the PAROC concern — merits attention. Many enterprises of this concern are equipping individual deposits in Norway and Finland. The production of GBR is done selectively according to type and sort. Careful quality control and multistage pre-homogenization of raw materials have been organized. All these factors enable the firm to produce high-quality wool consistently.

CONCLUSIONS AND RECOMMENDATIONS

To solve the raw materials problem successfully each producer must determine the requirements for the composition of the raw material that best meets the conditions of specific production, find a source of the required raw material and ensure the stability of the material entering the plant.

The problem is best understood for supplying lines for the production of mineral fiber based on blast furnace slag. The GBR consumption is small (thousands to a few tens of thousands metric tons per year). Owing to the extensive blending possibilities here the stability of the raw-materials composition and the logistics of the objects are paramount. Under such conditions it is impractical for a manufacturer to prepare private objects.

Enormous efforts are required to provision high-quality wool production. Depending of the location of the plant, GBR requirements, financial resources and relations with allied suppliers it is desirable for the manufacturer to prepare a private deposit or to partner with other mineral wool producers. A variant where supplies are obtained from objects producing construction stone or other useful minerals is possible. It is very likely that for any scenario the problems of preparing and organizing selective excavation and securing a stable raw-materials composition will be solved only with the direct participation of the party using GBR for mineral wool production.

The measures taken to obtain high-quality raw material will pay for themselves with interest in the final product owing to an increase in the service times of the melting units, decrease of energy consumption, improvement of fiber quality and, correspondingly, strengthening of the company's market position.

The trend observed in the last few decades definitely shows that high-quality fiber is displacing low-quality mineral wool, obtained using blast furnace slag, from the market. Together with the increase in the cost of fuel and operating expenses this unavoidably increases the role of GBR quality and stability, which is unrealistic without the development of an adequate mineral-raw materials base.

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